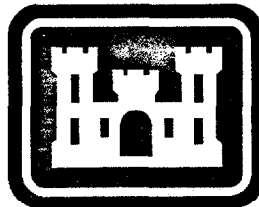


REVISED FINAL

Work Plan

Interim Corrective Measure Design
at Unit 2 (RSA-12, RSA-13, RSA-14,
RSA-131, RSA-132, and RSA-133)
Redstone Arsenal, Alabama

Prepared for:



U.S. ARMY CORPS OF ENGINEERS
Savannah District

EPA ID NO. AL2 210 020 742

Contract: DACA 21-91-D-0024

March 29, 1994

EBASCO ENVIRONMENTAL
A Division of Ebasco Services Incorporated

EPA ID NO. AL2 210 020 742

DELIVERY ORDER NO. 0007
UNDER
CONTRACT NO. DACA 21-91-D-0024
EBASCO SERVICES INCORPORATED

REVISED FINAL WORK PLAN
INTERIM CORRECTIVE MEASURE DESIGN AT UNIT 2
REDSTONE ARSENAL, ALABAMA

MARCH 28, 1994

EXECUTIVE SUMMARY

GENERAL

This Work Plan describes the services which the Ebasco Team will provide for the design of the Interim Corrective Measure (ICM) at Unit 2, the Open Burn/Open Detonation Area at Redstone Arsenal, Alabama. It is Ebasco's intent to design an ICM system for Unit 2 that will satisfy both the established goals of the ICM and provide for a biddable contract package.

Field Work

Ebasco will perform a field program to obtain additional field data required to complete the design of the ICM. This new task has been added based on the U.S. Environmental Protection Agency's (EPA's) review of Ebasco's Final Unit 2 Work Plan dated 26 February 1993. It is universally agreed among the EPA, U.S. Army Corps of Engineers, Redstone Arsenal and Ebasco that additional information is necessary to design an effective ICM system. Due to many hydrogeologic uncertainties, it is very difficult to predict if the designed extraction well locations will penetrate a productive geologic zone, and if the aquifer will yield the predicted flows and contaminant concentrations. Additional information about the total suspended solids, iron and metals concentrations also is needed to determine the magnitude of pretreatment required for the ICM system.

The field program will involve the installation of extraction wells, the proposed recovery mechanism for the ICM system. Ten extraction wells are planned for installation in the locations anticipated to produce the best results, based on the existing data. In order to expedite the field program to accommodate a tight design schedule, boreholes for each extraction well will be evaluated for productivity in the field during the drilling process. Only those wells meeting acceptable productivity limits will be converted to test wells. Unacceptable boreholes will be abandoned. Therefore, the possibility exists that less than ten wells will be installed. Based on existing data, however, it is assumed that some wells will yield more groundwater than necessary and compensate for unacceptable or lower yielding wells. Of the wells successfully installed, all will be developed for a period of four hours. Following development, three wells will be pump tested for 24 hours each. Each of the remaining wells will be specific capacity tested for a period of four hours. Groundwater extracted during development, pump testing and specific capacity testing will be sampled and analyzed. The results of the field program will indicate (1) if any of the selected extraction well locations are unfavorable, (2) what flow rate each well is capable of sustaining, (3) the estimated capture zone and drawdown of each well, (4) if the contaminants being sought (primarily TCE) are present at each selected location and depth, and (4) analytical data to characterize groundwater from the selected extraction well scheme.

Design Reports

The results of the field program will be analyzed, and Ebasco will prepare Design Reports for the installation and operation of the on-site groundwater recovery, treatment and disposal system. The recovery system design will include any modifications to the extraction well system installed during the field program. The Design Reports to be prepared include a Topographic Survey, Drawings, Specifications, System Design Analysis, and Health and Safety Design Analysis.

Installation and Operation Plans

Ebasco also will prepare Installation and Operation (I&O) Plans which describe how the designed facility will be installed and operated. These will include a Personnel Training Plan, Operations and Maintenance Plan, Installation Quality Control Plan, Field Sampling Plan, and Site-Specific Health and Safety Plan. Ebasco will submit detailed cost estimates for ICM installation and operation. Following a period of one year after system startup, Ebasco will analyze the operating conditions of the ICM and submit three additional reports: a Performance Evaluation Report, an Operations and Maintenance Manual, and a Service Contract Document.

Community Relations

In addition to the Design Reports, I&O Plans, cost estimates and follow-up reports, Ebasco will provide community relations support to the U.S. Army Corps of Engineers and to Redstone Arsenal throughout the duration of design activities.

INTERIM CORRECTIVE MEASURE

The ICM at Redstone Arsenal's Unit 2 is intended to be a short-term temporary remedy for a groundwater contamination plume that extends across the site. The ICM also will provide important design input data to be used in the final corrective measure and may itself be a major final remediation component.

Investigations of soil and groundwater were performed by another contractor and show that groundwater contamination consists primarily of chlorinated solvents. The bulk of solvent contamination is trichloroethylene (TCE), but also includes high levels of 1,2-Dichloroethene (DCE) and traces of other organic and inorganic contaminants.

The ICM for Unit 2 will consist of approximately 10 groundwater extraction wells and pumps, installed during the Unit 2 field program, and on-site discharge of treated groundwater. The treatment system will consist of ultraviolet (UV)/hydrogen peroxide (H₂O₂) oxidation with appropriate pre-treatment and post-treatment components. ICM installation, operation, and maintenance will be provided by the construction contractor with minimal oversight requirements from RSA staff, and is expected to continue at least through procurement for final corrective measures.

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SECTION 1.0 INTRODUCTION

- 1.0.a The U.S. Army Missile Command (MICOM) Environmental Management Office of Redstone Arsenal, Alabama, has tasked the U.S. Army Corps of Engineers (USACE), Savannah District (CESAS) to conduct an interim remedial action (IRA) at Unit 2, the Open Burn/Open Detonation Area at Redstone Arsenal. The project involves the design and construction of an Interim Corrective Measure (ICM) to mitigate groundwater contamination.
- 1.0.b The CESAS has tasked Ebasco Services Incorporated (Ebasco) under the Indefinite Delivery Order Contract DACA 21-91-D-0024 to prepare interim remedial design documents pertaining to the ICM at Unit 2. The objective of this Corrective Measures Design Work Plan is to describe the tasks which will be conducted during the performance of the project.

1.1 LOCATION

1.1.1 Redstone Arsenal

- 1.1.1.a Redstone Arsenal (RSA) is located in north central Alabama in the southwestern portion of Madison County as shown in **Figure 1-1: Location of Redstone Arsenal**. RSA is bounded by the City of Huntsville to the north and east, and the Tennessee River to the south. The towns of Madison and Triana are northwest and southwest of the Arsenal, respectively. Principal roadway access to the Huntsville area and RSA is provided by U.S. Highways 72, 231 and 431 and Interstate Highways 65 and 565.
- 1.1.1.b RSA encompasses approximately 38,300 acres. Of that area, 1,841 acres in the central part of RSA are leased to Marshall Space Flight Center (MSFC) of the National Aeronautics and Space Administration (NASA). The remaining 36,459 acres are controlled by the Department of the Army and support many land use functions. An additional 2,900 acres owned by the Tennessee Valley Authority (TVA) and 4,100 acres of Wheeler National Wildlife Refuge are located within the boundaries of RSA. Approximately 15,500 acres of RSA are woodlands and 9,200 acres are leased for agricultural use. Over 10,200 acres include maintained grassy areas, buildings, roads, and RSA facilities. The area surrounding the Arsenal is mixed containing light industry, residential, commercial and agricultural uses.
- 1.1.1.c The population of Madison County exceeds 250,000. Huntsville, located to the north of RSA, has a population of approximately 158,000. Approximately 1,000 military families reside in government quarters on RSA and approximately 31,500 government workers and contractors work at the facility.

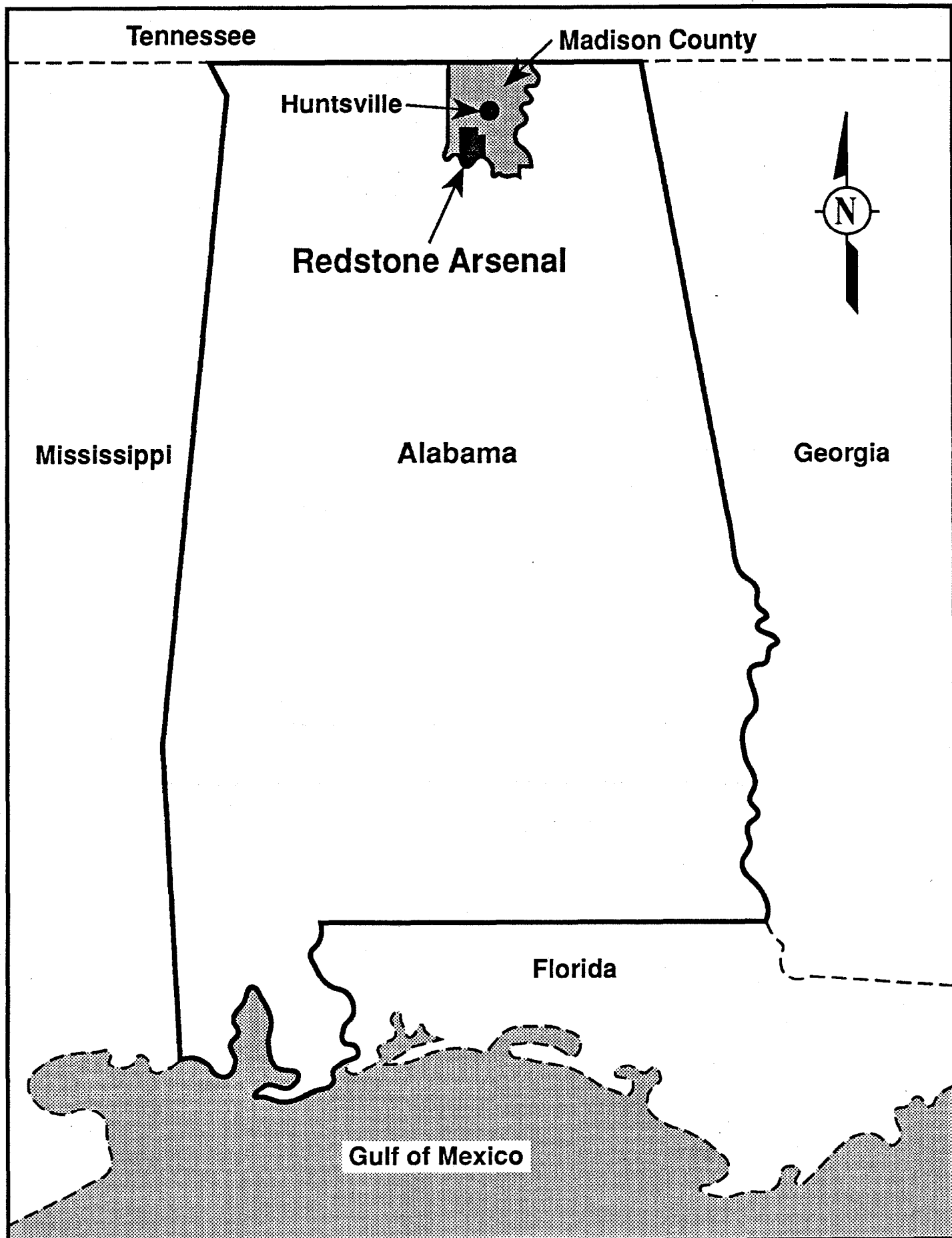


FIGURE 1-1 LOCATION OF REDSTONE ARSENAL

1.1.2 Unit 2

- 1.1.2.a Unit 2, the Open Burn/Open Detonation (OB/OD) Area, is approximately 89 acres in size and is located in the southern portion of RSA near the Tennessee River (**Figure 1-2: Location of Unit 2**). More than half of the OB/OD Area is within Tennessee Valley Authority (TVA) property on RSA. Areas to the west, north, and northeast of Unit 2 also belong to TVA. The southeastern portion of Unit 2 is within Army property bordered by TVA. Unit 2 has been separated into two areas: the "Contaminated Waste Burn Trenches" in the southeast portion of the site and the Open Burn Area and Open Detonation Area in the northwest portion (**Figure 1-3: Unit 2 - Open Burn/Open Detonation Area**). These areas are used to dispose of reactive wastes by thermal treatment. The reactive wastes include bulk propellants, propellant-contaminated solvents and nonhazardous propellant-contaminated waste such as rags and wood containing 4% or less propellant [Ref. 8.17]. Explosives and explosive-contaminated materials are decontaminated on site by detonation in an area on the northern end of Unit 2.

1.2 PHYSIOGRAPHY

1.2.1 Climate

- 1.2.1.a The climate at RSA is mild and temperate with an average annual temperature of 62°F. The average summer temperature is 77°F and the average winter temperature is 47°F. The average annual snowfall is 3 inches and the average annual rainfall is 48 inches. Total monthly precipitation is usually highest in March (5.6 inches) and lowest in October (2.7 inches). The last frost in the spring is typically no later than April 5, and the first frost in the fall occurs around October 31. Floods are common from mid-December to mid-April, although extensive flooding is infrequent. The 100-year flood level of the Tennessee River is at an elevation of 572.5 feet above mean sea level (msl). Moderately dry conditions generally prevail throughout autumn.
- 1.2.1.b Madison County experiences a prevailing southeast wind, but winds from the north and south also are common. The strongest winds are recorded in the winter, while mild winds persist throughout the summer.

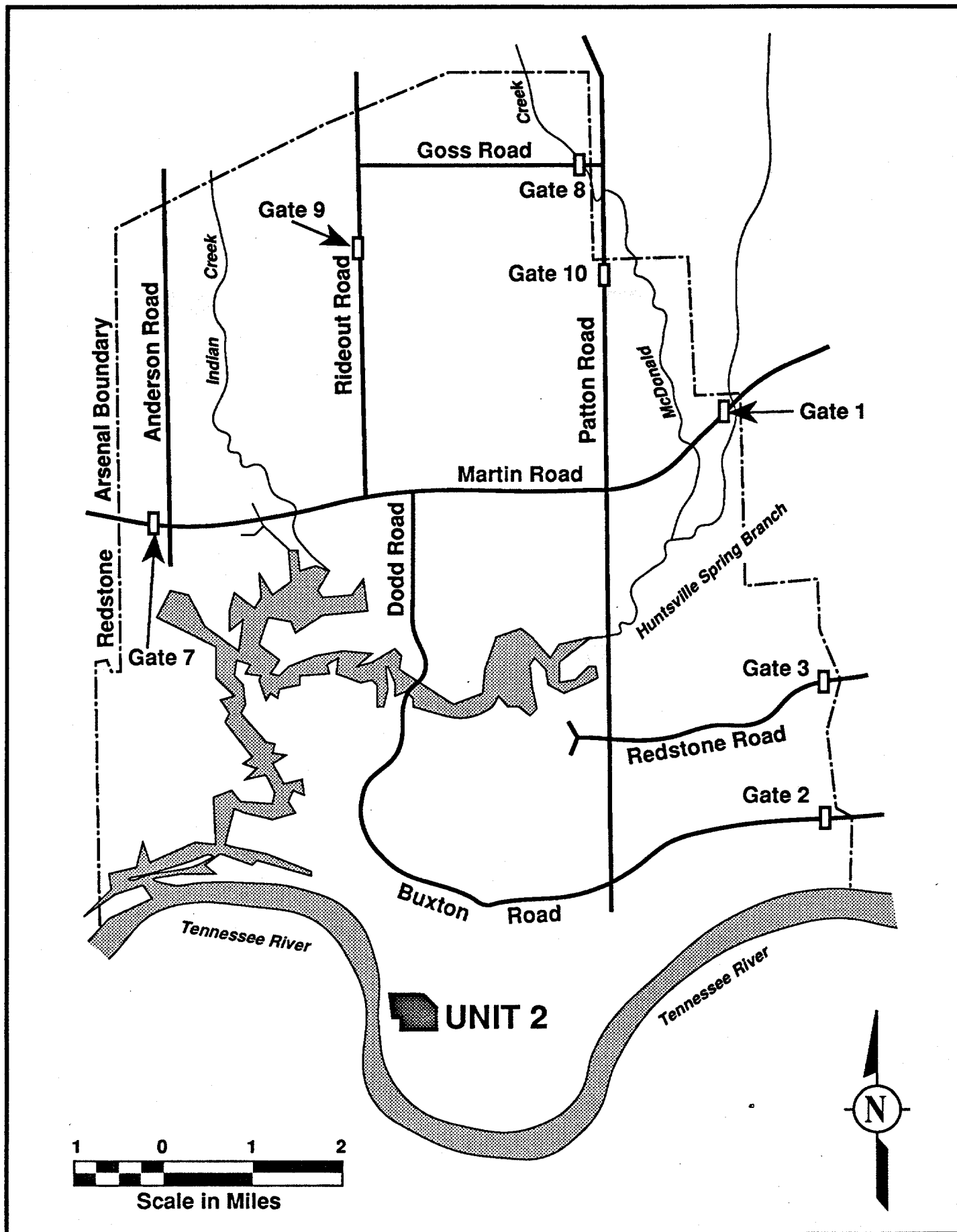


FIGURE 1-2 LOCATION OF UNIT 2

SECTION 2.0 INTERIM CORRECTIVE MEASURE

- 2.0.a The Interim Corrective Measure (ICM) for Unit 2 is focused on accomplishing both short-term and long-term goals as discussed in the ICM Design kickoff meeting held at RSA on November 16 and 17, 1992. In the short-term, aggressive interim groundwater remediation efforts are anticipated to start within a few months of ICM design completion and construction contractor procurement. On a longer-term basis, the ICM will provide important design input data to be used in the final corrective measure design.
- 2.0.b This ICM Work Plan presents a proposed engineering method for partial remediation and control of groundwater contamination at Unit 2. The design methodology is based on a review of all available technical documents, an analysis of several alternative remedial processes and technical engineering judgements of interim measures which best fit the characteristics of the Unit 2 site. The conclusions presented in the technical documents reviewed are briefly presented in various sections throughout this Work Plan. It is recommended that the reader refer to the previous investigation documents described in Section 1.4 for details related to the site data, site description, analysis results, etc.
- 2.0.c In order to facilitate design of the ICM, Ebasco will perform a Field Program to obtain additional field data at the Unit 2 site. This new task has been added based on the U.S. Environmental Protection Agency's (EPA's) review of Ebasco's Final Unit 2 Work Plan dated 26 February 1993. It is universally agreed among the EPA, USACE, MICOM Environmental Management Office at RSA, and Ebasco that additional information is necessary to design an effective ICM system. Due to many hydrogeologic uncertainties at the site, it is very difficult to predict if the proposed extraction well locations, described in this section, will penetrate a productive geologic zone; and if the aquifer will yield the predicted flows and contaminant concentrations. Additional information about the total suspended solids, iron and metals concentrations also is needed to determine the magnitude of pretreatment required for the ICM system. The scope of the proposed Field Program is discussed in Section 3.1 - Additional Data Requirements of this Work Plan.
- 2.0.d The ICM for Unit 2 will consist of groundwater extraction using extraction wells and pumps, treatment of extracted groundwater to remove or destroy organic contaminants, and on-site discharge of treated groundwater. ICM operation and maintenance will be provided by the construction contractor (or subcontractor) with minimal oversight requirements from RSA staff, and is expected to continue at least through procurement for final corrective measures. The final corrective measure may or may not utilize the ICM installation, depending upon the most cost effective approach to the final cleanup remedy.

2.1 GROUNDWATER COLLECTION SYSTEM

- 2.1.a The reader should refer to Section 3.1 of this Work Plan for a clear understanding of how the proposed Field Program, discussed above, fits into the design of the ICM system. In general, the Field Program will consist of the installation of a portion of the groundwater collection system described in this section, specifically the extraction well network. To avoid confusion, this section should be interpreted to describe the groundwater collection system that will be installed as part of the whole ICM system, with the understanding that the extraction well network will already be installed when the ICM is constructed. It is possible, however, that based on the results of the Field Program, modifications to the extraction well network will be made during the ICM design. One objective of the Field Program is to obtain information to refine the extraction well design.
- 2.1.b Ebasco recommends an approximate extraction well layout as shown in **Figure 2-1: Conceptual Extraction Well Configuration**. This layout addresses the design criteria described in the following sections. Although it was first proposed to install an extraction well northeast of the Unit 2 site (near well RSA 61), further evaluation based upon a site visit and examination of topographic maps has led to the determination that placing a well in that location would prove costly for an interim corrective measure. Extensive piping would be required to include this well in the network. An alternative location, midway between the two well fields and southeast of the Rocket Washout Pad, has been selected (Figure 2-1). It is expected that this well will produce equally meaningful results.
- 2.1.c Ebasco recommends that the ICM design provide for ten (10) extraction wells covering the extent of the two contamination plumes at Unit 2. The well layout shown in Figure 2-1 is approximate because final extraction well placement will be optimized in the field to the extent possible by selecting favorable hydrogeologic conditions from among the well boreholes. The following sections describe the basis and approach for laying out the extraction system, and the criteria which will be used in the field to determine if a well borehole exhibits favorable hydrogeologic characteristics which justify completion of a well in that location.

2.1.1 Design Flow Rate

2.1.1.a A calculation of proposed pumping rates was performed for the Unit 2 area based on data obtained from the RCRA Field Investigation at Unit 2 [Ref 8.25], as well as data from actual slug tests performed at Unit 1, another site on Redstone Arsenal. This data, together with an assumed well diameter and assumed effective porosity based on engineering judgement, was used to calculate a flow rate of approximately 20 to 25 gpm. However, due to the uncertainty associated with the fracture flow in the limestone bedrock aquifer at the site, the calculated extraction well flow rate is not particularly meaningful and will be measured during the Field Program.

2.1.1.b An analysis to show that extraction wells will sustain this calculated rate without dewatering the aquifer also can not be performed in any meaningful manner at this time. Proximity of the site to the Tennessee River and surrounding wetlands suggests that dramatic dewatering will not occur. However, it is desirable to avoid impacts to nearby wetlands and maintain as much contaminated aquifer material in contact with the groundwater as possible. Pump tests will be performed during the Field Program that are intended to demonstrate the actual boundary conditions, specific yield, and storage of the target aquifer. Once these data are obtained, it will be possible to plot drawdown versus time in the test wells and determine if dewatering (or a small radius of influence) are potential problems to be addressed.

2.1.2 Extraction Well Locations

2.1.2.a Well placement should emphasize the most highly contaminated areas of the overburden and upper bedrock (Tuscumbia Limestone) aquifers without attempting 100% plume capture (unrealistic and costly objective). The areal extent of the contamination plume is based on Geraghty & Miller, 1992 [Ref. 8.25] total chlorinated hydrocarbon concentrations in the overburden (contours on Figure 2-1), the TCE concentrations in the bedrock aquifer that includes eleven upper bedrock and eleven deep bedrock wells (Figure 2-2: TCE Contamination - Upper Bedrock), and the top of bedrock structure map (Figure 2-3: Structure Map - Top of Tuscumbia Limestone).

2.1.2.b With data being sparse in the upper bedrock aquifer, Figure 2-2 was constructed with the assumption that the contamination in the upper bedrock would be at least as high as that in the lower bedrock aquifer. This assumption allowed using analyses from the eleven deeper wells, and resulted in a contamination plume outline consistent with the overburden plume. The deep aquifer contamination seems to be elongated along the northwest-southeast structure, and probably reflects a karst or fracture zone associated with this structure.

- 2.1.2.c The top of Tuscomb Limestone structure map shows a northwest to southeast anticlinal ridge crossing Unit 2 (Figure 2-3). The Open Burn and Detonation Areas in the northwest section of Unit 2 are located on or near the crest of this high. This structural high will influence groundwater flow and contaminants to assume a radial pattern in the overburden and upper bedrock aquifers. This radial flow pattern was confirmed by Geraghty & Miller, 1992 deep overburden and upper bedrock hydraulic head elevation maps showing direction of horizontal hydraulic gradient (Figures III-5 and III-6, Appendix C). The circular nature of the contaminant plume in this area also confirms this hypothesis.
- 2.1.2.d The Contaminated Waste Burn Trenches area in the southeast section of Unit 2 is located off the end of this structural high and to the north of an associated high. These bounding structures to the west and south coupled with a structural low to the northeast probably are the controlling factors in the northeast elongated contaminant plume.
- 2.1.2.c Due to the fracture flow system, maximum flow rates from each individual well will vary considerably. Also, the actual "capture zone" from each well may be unique in that water will flow through the intersected fracture network for that specific well. Due to this high variability, Ebasco recommends installation of a series of ten wells distributed equally in each of the two contaminant plumes at Unit 2. Based on simplified analysis of groundwater flow and allowing for flow rates in the 20 to 25 gpm range per well, ten wells are required to meet the criteria of 60 percent plume interception established by EPA. A discussion of the criteria which will be used during the Ebasco Field Program to install these wells is contained in Section 3.2 of this Work Plan. It should be noted that the number and/or locations of extraction wells installed during the Field Program can be adjusted during design of the ICM.
- 2.1.3 Extraction Zones**
- 2.1.3.a Well screens will be placed to maximize the groundwater extraction in the Upper Bedrock/Deep Overburden zone. There is no direct data to confirm the assumption that pumpage from the bedrock zone will control contaminant migration in the overburden aquifers. There is indirect evidence, based on boring logs showing an absence of aquicludes, that the overburden and bedrock aquifers are connected. However, this connection may be poor, or the bedrock may be a leaky artesian condition that only pump tests can determine. The Field Program is intended to provide direct measurement of the effect of bedrock groundwater removal has on the potentiometric surface of the overburden zones. At this time, it is assumed that if migration rates in the overburden aquifers are significant, then there should also be a greatly increased downward flow from the overburden aquifers to the extraction well inlets under the influence of a lowered bedrock potentiometric surface.

2.1.4 Extraction System Operation

- 2.1.4.a The criteria for operation will be 24 hour, automatic continuous operation with controls for site-specific variations and performance optimization. The extraction system will incorporate control logic that functions with treatment system operations and controls.

2.2 GROUNDWATER TREATMENT SYSTEM

- 2.2.a The primary organic constituents of concern at the Unit 2 site which require treatment include trichloroethylene (TCE) and 1,2-Dichloroethylene (DCE). Additional contaminants found include other organics, metals and compounds indicative of explosives. Table 2-1 provides a list of the contaminants detected at Unit 2 during the Phase I and Phase II RFI conducted by Geraghty and Miller [Refs. 8.17 and 8.25].
- 2.2.b The groundwater treatment system will fully address all known site contaminants and their treatment by-products. However, the treatment system sizing will be based on total chlorinated hydrocarbons (TCH). It is anticipated that all other known contaminants (organic and inorganic) will be remediated to acceptable discharge limits by either (1) volatilization in the UV/H₂O₂ system, (2) removal in a pretreatment system, or (3) removal in pre and/or post treatment filters, if required. The design basis influent concentration of 30,000 ppb TCH is based on the approximate average of the extracted groundwater concentrations from the shallow bedrock/deep overburden at Unit 2. Data from Figure III-9 (Appendix C) of the Geraghty and Miller RFI [Ref. 8.25] shows that well Number 106, located adjacent to a proposed extraction well, has a TCH concentration over 150,000 ppb. Assuming that the other extraction wells produce some concentration above zero, the average will be above 30,000 ppb for the proposed eastern field of five wells. However, there also is expected to be some slow reduction in influent concentration over time; therefore, the value of 30,000 ppb TCH was selected. Chemical analyses of extracted groundwater conducted during the Field Program will provide the data necessary to sufficiently characterize the groundwater contamination at the site.
- 2.2.c Groundwater quality sampling and analysis performed by Ebasco in July, 1993 at Unit 2 indicate that groundwater in the area consists of high levels of iron (up to 150 ppm) and total suspended solids (up to 1,600 ppm). The groundwater treatment system will consist of equipment to remove organic contaminants to a level that can be discharged to nearby surface water, controls for maintaining continuous unattended operation, and all associated equipment and appurtenances. Based on the high levels of iron and suspended solids, a pretreatment system also is required. The extent of pretreatment required will be determined during the

TABLE 2-1 CONTAMINANTS DETECTED AT UNIT 2

PARAMETER	MAXIMUM DETECTED IN GROUNDWATER	MAXIMUM DETECTED IN SOIL	REGULATORY LIMITS			
			EFFLUENT WATER (µg/L)	SOURCE OF LIMIT	WASTE BYPRODUCT (mg/L)*	SOURCE OF LIMIT
VOLATILE ORGANICS	(µg/L)	(µg/Kg)				
Trichloroethene	98,000	6,100,000	5	MCL	0.5	40 CFR Part 261
1,1,1-Trichloroethane	1,300	730,000	200	MCL		
Carbon Tetrachloride	18	ND	5	MCL	0.5	40 CFR Part 261
Tetrachloroethene	860	31,000	5	MCL	0.7	40 CFR Part 261
Acetone	2,100	37,000				
Toluene	21	12,000	1,000	MCL		
Total Xylenes	640	22,000	10,000	MCL		
Vinyl Chloride	670	410	2	MCL	0.2	40 CFR Part 261
Ethylbenzene	7	4,000J	700	MCLG		
Benzene	410	95	5	MCL	0.5	40 CFR Part 261
Carbon Disulfide	ND	51				
Chlorobenzene	50	ND	100	MCL	100.0	40 CFR Part 261
Chloroform	810	8,000	56.91	HHC	6.0	40 CFR Part 261
1,1-Dichloroethane	150	13				
1,2-Dichloroethane	130	13	5	MCL	0.5	40 CFR Part 261
1,1-Dichloroethene	2,100	16,000	7	MCL	0.7	40 CFR Part 261
1,2-Dichloroethene (total)	48,000	1,200	cis 70 tran 100	MCL MCL		
Methylene Chloride	410	110,000	46.54	HHC		
1,1,2,2-Tetrachloroethane	30	ND	1.72	HHC		
1,1,2-Trichloroethane	2J	ND	6.05	HHC		

PARAMETER	MAXIMUM DETECTED IN GROUNDWATER	MAXIMUM DETECTED IN SOIL	REGULATORY LIMITS			
			EFFLUENT WATER	SOURCE OF LIMIT	WASTE BYPRODUCT	SOURCE OF LIMIT
BASE/NEUTRAL AND ACID EXTRACTABLE ORGANICS	($\mu\text{g/L}$)	($\mu\text{g/Kg}$)	($\mu\text{g/L}$)		(mg/L)*	
Bis(2-ethylhexyl)phthalate	100	330J	17.58	HHC		
Bis(2-chloroethoxy)methane	< 10	ND				
Di-n-butyl phthalate	ND	320J				
Phenol	< 10	ND				
TOTAL METALS	($\mu\text{g/L}$)	(mg/Kg)	($\mu\text{g/L}$)		(mg/L)*	
Arsenic	16	11.8	50	MCL	5.0	40 CFR Part 261
Barium	707	431	1,000	MCL	100.0	40 CFR Part 261
Cadmium	42.6	11.5	10	MCL	1.0	40 CFR Part 261
Calcium	10,400					
Chromium	85.9	36.6	50	MCL	5.0	40 CFR Part 261
Iron	3,100	NA	300	SMCL		
Lead	35.7	73.7	50 20	MCL Alabama	5.0	40 CFR Part 261
Mercury	4.2	0.24	2	MCL	0.2	40 CFR Part 261
Selenium	16.5J	0.62J	10	MCL	1.0	40 CFR Part 261
Silver	ND	12.6	100 50	SMCL Alabama	5.0	40 CFR Part 261
Sodium	17,600	NA				

PARAMETER	MAXIMUM DETECTED IN GROUNDWATER	MAXIMUM DETECTED IN SOIL	REGULATORY LIMITS			
			EFFLUENT WATER	SOURCE OF LIMIT	WASTE BYPRODUCT	SOURCE OF LIMIT
EXPLOSIVES	($\mu\text{g/L}$)	($\mu\text{g/g}$)				
HMX	ND	5.05 (sediment)				
RDX	7.41	1.43				
PETN	ND	22.3				
2,4-Dinitrotoluene	4.9	0.839	9.36	HHC		
1,3-Dinitrobenzene	0.861	NA				
1,3,5-Trinitrobenzene	46.3	1.16				
2,4,6-Trinitrotoluene	ND	857				
2,6-Dinitrotoluene	ND	0.746 (sediment)				
OTHER-GENERAL WATER QUALITY	(mg/L)		(mg/L)			
Magnesium	6.22	NA				
Manganese	0.785	NA	0.050	SMCL		
Potassium	1.8	NA				
Total Alkalinity as CaCO_3	20	NA				
BOD (5-day)	ND	NA				
Chloride	11	NA	250	SMCL		
COD	20	NA				
Hardness as CaCO_3	56	NA				
Oil and Grease	ND	NA				
Sulfate	5	NA	250	SMCL		

PARAMETER	MAXIMUM DETECTED IN GROUNDWATER	MAXIMUM DETECTED IN SOIL	REGULATORY LIMITS			
			EFFLUENT WATER (mg/L)	SOURCE OF LIMIT	WASTE BYPRODUCT	SOURCE OF LIMIT
	(mg/L)					
Total Dissolved Solids	350	NA	500	SMCL		
Total Organic Carbon	ND	NA				
Total Suspended Solids	218	NA				

Notes:

Blank entries occur where regulatory limits do not currently exist.

* - In TCLP Extract of Sludge

HHC - Human Health Criteria

J - Estimated Value

MCL - Maximum Contaminant Level

MCLG - Maximum Contaminant Level Goal

NA-Not Analyzed

ND - Not Detected

SMCL - Secondary Maximum Contaminant Level

Field Program. It is anticipated that the treatment equipment and supplies will be housed in a prefabricated shelter with considerations for site access, site flood conditions, current RSA activities within Unit 2, and adjacent land uses. **Figure 2-4: Tentative Treatment System and Discharge Point Locations** shows the optimum location of the system based on the currently available site data. This location is at an elevation above the 100 year flood plain (572.5 ft msl) and also satisfies the Arsenal's "safe distance" criteria for permanent, manned structures by being removed an adequate distance away from the active OB/OD portion of Unit 2.

- 2.2.1.f Ebasco believes that the biological treatment process is not feasible for the Unit 2 site for the following reasons: (1) contaminant concentrations are too low to sustain biological growth, (2) a carbon source and other nutrients are needed to properly maintain the process, (3) groundwater flows are not steady and (4) other technologies appear less sensitive and more appropriate to be used at the site. Other technologies considered applicable for this application are: the advanced oxidation process, the liquid phase carbon adsorption process, air stripping, the air stripping process with liquid phase carbon polishing, the air stripping process with off-gas treatment by Catalytic Oxidation, and the air stripping process with both off-gas treatment by GAC and polishing treatment by GAC.

Economic Evaluation

- 2.2.1.g The economic evaluation is provided to establish the most cost effective treatment system based on a full service contract provided by the contractor over the anticipated life of the treatment program. Under the full service contract, the contractor will provide the treatment systems which include equipment, maintenance, replacement parts, emergency service and regular service. The contractor will guarantee that the performance of the system will meet the discharge effluent limitations. All of these services are included in the monthly service fee. The treatment options under evaluation are:

- Option 1 - Advanced Oxidation Process
- Option 2 - Liquid Phase Carbon Adsorption Process
- Option 3 - Air Stripping
- Option 4 - Air Stripping with Liquid-Phase Carbon Adsorption
- Option 5 - Air Stripping with Catalytic Oxidation of VOCs in the Vapor Phase
- Option 6 - Air Stripping with Vapor Phase and Liquid Phase Carbon Adsorption

The design criteria for the six (6) treatment options are:

1. Maximum flow rate is 250 gpm.
2. Treatment criteria are drinking water standards, Maximum Contaminant Levels (MCLs) or Maximum Contaminant Level Goals (MCLGs)
3. Influent contaminant concentration is 30,000 ppb Total Chlorinated Hydrocarbons.

A Relative Cost Analysis for the six (6) options is shown as follows:

TREATMENT OPTIONS						
	1	2	3	4	5	6
1. Initial Setup Fee	5,500	75,000	30,000	54,000	105,000	105,000
2. Monthly Service Fee	7,800	5,500	3,500	4,900	10,000	9,000
3. Monthly Power Costs	3,582	150	400	470	1,100	600
4. Additional Carbon Cost Per Year	0	348,000	0	3,400	0	88,000
5. One Air Stripper	0	0	55,000	55,000	55,000	55,000
6. One Catalytic Incinerator	0	0	0	0	150,000	0
TOTAL ESTIMATED COST FOR TWO-YEAR TREATMENT	278,700	906,600	178,600	244,680	576,400	566,400

2.2.2 Selection of Treatment Technology

2.2.2.a All treatment options evaluated for the ICM are technically feasible in terms of meeting surface water discharge requirements. However, Option 3, Air Stripping without off-gas treatment is not feasible because without extensive studies, the State limits TCE discharge to air to 0.1 lbs/hr. Based on the design criteria listed in paragraph 2.2.1.g, it is anticipated that between 3 and 4 lbs/hr total chlorinated hydrocarbons would be emitted using air stripping, which is 30 to 40 times too high. The remaining options (1,2,4,5 and 6) are all technically feasible based on both regulatory requirements and discharge requirements.

2.2.2.b Ebasco recommends that UV Oxidation be required for the treatment technology, both for its lower cost and several added benefits including:

- UV Oxidation destroys all the organic contaminants to very low levels making permitting the discharge simpler.
- UV Oxidation will not require extensive treatability testing because the technology is not extremely sensitive to contaminant loading.
- UV Oxidation will not result in spent carbon disposal requirements or periodic cleaning of stripping tower packing.

- UV Oxidation does not transfer the contaminant from water to air, an action which would trigger air dispersion modeling requirements and increased monitoring expenses.

2.2.2.c In the presence of UV radiation, the rate of oxidant decomposition is accelerated, with a corresponding increase in the rate of hydroxyl radical formation. Organic molecules that have adsorbed UV energy are in an excited state and are more susceptible to attack. Therefore, the rate at which organic compounds are oxidized is significantly higher than that attained by using UV radiation or chemical oxidants alone. Previous studies of the UV/chemical oxidation process indicate that the overall reaction mechanism displays first-order rate kinetics with respect to the contaminant concentration oxidant dosage, and UV intensity.

2.2.2.d Organic carbon, soluble iron and manganese, and other constituents which produce general turbidity can reduce the efficiency of the UV/chemical oxidation process by reducing the amount of UV energy available for adsorption by the organic contaminants and the chemical oxidant. Organic carbon will compete with the constituent of concern by adsorbing UV energy and consuming oxidant. Soluble iron and manganese will oxidize to their insoluble form, thereby directly competing with the contaminant for UV energy and oxidant. Highly turbid water will reduce UV intensity in a similar manner. The effect of these factors generally can be dealt with either through pretreatment or by considering their effects during the design process. The magnitude of pretreatment required will be determined upon completion of the Ebasco Field Program described in Section 2.0.

2.3 TREATED WATER DISPOSAL

2.3.a Options for treated water disposal include reinjection via wells back into the aquifer, spray field application, recharge gallery, and point discharge to a surface water body. Discussions with the Alabama Department of Environmental Management (ADEM) regarding each option indicate that each is feasible in terms of permitting, but spray field (or land application) and reinjection may involve the most difficulties, primarily resulting in the need for additional site specific data and impact studies. For purposes of this ICM, point discharge appears to be the best option based on the following reasons:

- Aquifer Reinjection: Reinjection is not recommended because at this stage of site characterization there is the risk that an improperly placed injection well(s) could spread contamination rather than push it toward a recovery well. Furthermore, proper design of an injection system is dependent upon a thorough site characterization, including injection testing, and should be carefully modeled with a properly documented and supportable digital flow model. Finally, reinjection is often used where recharge boundaries are

poorly defined or difficult to predict. At Unit 2, proximity to the river and other considerations suggest that there will be sufficient natural recharge to the extraction areas.

- **Spray Field/Land Application:** This option typically will require from 100 to 500 acres for a flow of 250 gpm. Land area requirements of potentially a square mile are probably not realistic under the constraints of the Unit 2 area. Furthermore, discussions with ADEM suggest that this option may be the most difficult to permit in terms of time and ADEM requirements. Therefore, this option is not recommended.
- **Recharge Gallery:** A recharge gallery is not recommended for the same reasons aquifer reinjection is not recommended. Proper recharge gallery design would require additional site data and could risk adverse impact on plume containment.
- **Point Discharge:** Point discharge will require National Pollutant Discharge Elimination System (NPDES) permitting and appears to be the most technically feasible disposal option. Based on communications with ADEM, permitting an outfall of the type expected from the ICM treatment system should be relatively straight forward.

2.3.b

Figure 2-4: Tentative Treatment System and Discharge Point Locations, indicates the most desirable location for the outfall from the treatment system. This location was chosen as a result of a site visit conducted on February 1, 1993 by an Ebasco design engineer and hydrologist. The proposed discharge area currently receives drainage from ditches in the vicinity, and in turn discharges to the Tennessee River. It is anticipated that treated water from the ICM system will be discharged via a pipeline that follows the existing north-south fenceline traversing Unit 2. The proposed discharge point is strategically located near the fence. Selection of the final discharge point will be determined following discussions with ADEM. It will be necessary to modify RSA's existing NPDES permit to include the proposed outfall location. Pretreatment effluent such as treatment sludge and solid metals precipitate will be sampled to determine proper handling procedures and disposal locations. The preparation of a Disposal Plan will be required prior to ICM construction.

2.4

ELECTRICAL DESIGN

2.4.a

The following general items will be considered in the electrical design:

- The proposed treatment building location is above the 100 year flood plain of the Tennessee River; therefore, power drops, panels, and other equipment not otherwise protected by the design of the treatment building

will not be endangered by potential floods. It is expected that in most cases, water-proof components will be specified.

- Power requirements are anticipated to be on the order of 170 KW, or approximately 230 horse power. These power requirements will entail special consideration of current site use and selection of the location for power takeoff.
- Operational control/kill switches will be included to protect against power losses or system malfunctions.

2.5 MECHANICAL DESIGN

2.5.a The mechanical design will include all piping, pumps, valves, metering and well head appurtenances not otherwise provided in the electrical design. The following criteria and design options will be considered in the design of the mechanical system:

- Except for road crossings, piping will be above grade with heat-tracing to facilitate freeze protection. The use of above grade piping is preferred to avoid the requirement for clearing the site of potential unexploded ordnance prior to trenching. Above grade piping also will facilitate pipe inspection and maintenance.
- The long distances (potentially up to 2000 feet) from extraction wells to treatment system may result in the need for a transfer or lift station centrally located in each of the extraction well fields. If technically and economically feasible, only submersible pumps with sufficient head for both lift and flow head loss will be used to extract and convey water to the treatment system.
- Piping material will be selected based on material compatibility and expected operation characteristics. If possible, non-rigid piping will be used to minimize construction cost and minimize joints where leakage is likely to occur.

2.6 CIVIL DESIGN

2.6.a Civil design will include the drawings and specifications for temporary roads, drainage, pre-engineered building foundation, pipe and cable installation below road crossings, and channel improvements at the treated water discharge point. Criteria for design of these ICM components will include the following:

- Roads will be temporary and are intended to facilitate routine maintenance of ICM components and systems.

SECTION 3.0 TECHNICAL APPROACH TO ICM DESIGN

- 3.0.a** Ebasco's technical approach to the ICM Design is based upon the design criteria and assumptions presented throughout this section. A summary of these design criteria is presented in **Appendix B**.

3.1 ADDITIONAL DATA REQUIREMENTS

3.1.1 Ebasco Field Program

- 3.1.1.a** In order to facilitate design of the ICM, Ebasco will perform a Field Program to obtain additional field data at the Unit 2 site. This new task has been added based on the U.S. Environmental Protection Agency's (EPA's) review of Ebasco's Final Unit 2 Work Plan dated 26 February 1993. It is universally agreed among the EPA, U.S. Army Corps of Engineers, Redstone Arsenal and Ebasco that additional information is necessary to design an effective ICM system. Due to many hydrogeologic uncertainties, it is very difficult to predict if the designed extraction well locations will penetrate a productive geologic zone, and if the aquifer will yield the predicted flows and contaminant concentrations. Additional information about the total suspended solids, iron and metals concentrations also is needed to determine the magnitude of pretreatment required for the ICM system.

- 3.1.1.b** The scope of the proposed Field Program basically involves the installation of the extraction well network described in Section 2.0 of this Work Plan, and the subsequent collection of chemical and physical data from those wells. The data to be obtained is described in the following paragraphs.

3.1.1.c Pump Test Data

The Karst geology at the site is anticipated to be highly unpredictable in terms of groundwater extraction rates and areal capture of contaminants. In order to carefully plan and predict the performance of the ICM extraction well system, a network of boreholes will be drilled, evaluated, and converted to pump test wells. The data that will be obtained from this drilling and testing effort includes:

- Optimum screen interval to maximize areal capture for each wells, and to maximize fracture interception;
- Optimum spacing of wells to obtain effective capture of contaminants migrating off-site;
- Specific yield from each well, and the associated flow rate from the entire extraction well system at the desired capture; and

- Measured vertical influence of the extraction well system to predict overall contaminant capture over the entire groundwater column.

These data will be used to properly size the capacity of the groundwater treatment system.

3.1.1.d Chemical Analytical Data

Design of the groundwater treatment system will be based on data collected from groundwater samples collected during the pump tests. These data will include measurement of the dissolved solids, iron, and other parameters required to design and size a pretreatment system. Additional data will include analyses for metals and organics suspected of being present in the groundwater. These contaminants include all metals and organics detected during previous investigations.

- 3.1.1.e Because the Field Program precedes the ICM, field selection of the number, locations, and depths of the extraction wells can be painstakingly accomplished without delaying other portions of the ICM construction. More importantly, the data which will be obtained during the Field Program will be used in the design of the pretreatment and treatment system. If the groundwater extraction wells were to be installed at the same time as the rest of the ICM system, there would be no time to collect and analyze actual site data prior to installation of the pretreatment and treatment systems. Subsequent modifications to the system would be costly and can be prevented by obtaining the necessary data prior to design.

3.1.2 Treatability Studies

- 3.1.2.a Treatability testing will be conducted as part of the Ebasco Field Program at Unit 2. Groundwater extracted during the installation of the ten extraction wells (from well development and pump testing) will be treated using a pilot scale system of the proposed ICM treatment technology, UV/H₂O₂ Oxidation. The purpose of the study is twofold: it will provide treatability data essential to sizing the proposed full-scale ICM UV/H₂O₂ Oxidation system, and it will provide treatment of the contaminated groundwater generated during the Field Program.

- 3.1.2.b The pilot scale system will include all of the components of a full size system, including pre- and post-treatment filters, required to produce treated water meeting NPDES Permit discharge limits. Effluent from the pilot scale system will be discharged to the proposed discharge location of the ICM system, described in Section 2.3. Ebasco will prepare an application to modify Redstone Arsenal's existing NPDES permit to include the proposed outfall location for the period of the Field Program only. The following section discusses NPDES permitting for the Field Program and the ICM.

3.1.3 Receiving Water Survey

- 3.1.3.a Potential impacts to the stream and wetlands due to continuous discharge from the treatment system should be evaluated early in the design process and prior to Draft Design submittal. On February 1, 1993, an Ebasco design engineer and Ebasco hydrologist conducted a field investigation at the Unit 2 site. The stream survey consisted of measurements of channel depth and width from the treatment discharge point to the point the stream discharges to the river. Analysis of the data will include simple hydraulic computer modeling to obtain flow velocities and maximum flow conditions. The stream survey will be included as a calculation in the Design Analysis. No additional stream data is required for this design.
- 3.1.3.b In order to discharge any treated water at the proposed discharge location (Figure 2-4), an application must be submitted to ADEM to modify Redstone Arsenal's existing NPDES permit to include the proposed outfall location for the discharges proposed. In this instance, the Field Program at Unit 2 and the future ICM at Unit 2 will be handled separately. One application will be submitted to request permission to discharge treated water during the Field Program. Permission to discharge during the life of the ICM will be requested separately at some time in the future.

3.2 DESIGN OF GROUNDWATER COLLECTION SYSTEM

This section describes the extraction well network proposed for the ICM system. As described in this Revised Final Work Plan, the Field Program to be conducted by Ebasco involves installation of this extraction well network.

3.2.1 Well Field Layout

3.2.1.a **Figure 2-1: Conceptual Extraction Well Configuration** (see Section 2.0, page 2-3), shows a preliminary layout of extraction wells. The purpose of Figure 2-1 is to present tentative extraction rates, number of wells and the extent of plume capture. Actual placement of wells will be adjusted during the implementation of the Ebasco Field Program. These tentative recovery well locations are based on permeability data and groundwater contamination contours from the Draft Final RCRA Facility Investigation by Geraghty and Miller, 1991, and the Draft Phase II Addendum, also by Geraghty and Miller, October 1992. These reports by Geraghty and Miller are fully referenced in Section 8.0, and were furnished to Ebasco by CESAS for the purpose of supporting the ICM design effort. Key figures and tables to be used in determining the well layout are excerpted from these reports and are included in **Appendix C** to this Work Plan. Using these data, the well layout was determined using the following approach:

- Slug test permeability data for the deep overburden and upper bedrock were used to obtain a representative areal average permeability. Data extremes, such as permeabilities several orders of magnitude above the average will be deemphasized or not used in the calculation.
- The Theis Equation was used to obtain drawdown versus distance assuming: 1) storage coefficient of 0.15; 2) equilibrium conditions will be achieved within 20 days of initial pumping, and; 3) an saturated thickness of 40 feet.
- Approximately 10 feet of theoretical drawdown in the pumped well was used as the design criteria, assuming an saturated zone of 40 feet. Based on Ebasco's experience, it is desirable to allow for up to 50% well inefficiency which will double well drawdown at a given pump rate.
- Approximately one foot of drawdown at the edge of the capture zone will be necessary to overcome natural gradients.
- Contamination contour maps from the Geraghty & Miller reports, derived from existing contaminant data; the top of bedrock structure map; and horizontal hydraulic gradient maps (See Figures 2-1 to 2-3; Figures III-5 and III-6, Appendix C) were the basis for laying out approximately five wells in each of the separate plume areas for a total of ten extraction wells.

- 3.2.1.b The simplified technical approach to designing an extraction well field such as described above will be used for design of the ICM and is justified when there is a significant lack of aquifer data, particularly pump test data. During the Field Program, Ebasco will obtain the necessary pump test data to obtain measurements of the boundary recharge conditions. These data are model input parameters essential in order to realistically simulate aquifer responses to stresses.
- 3.2.1.c In order to expedite the field program to accommodate a tight design schedule, boreholes for each extraction well will be evaluated for productivity in the field during the drilling process. Only those wells meeting acceptable productivity limits, as defined below, will be converted to test wells. Unacceptable boreholes will be abandoned. Therefore, the possibility exists that less than ten wells will be installed. Based on existing data, however, it is assumed that some wells will yield more groundwater than necessary and compensate for unacceptable or lower yielding wells. All wells will be developed. Of the wells successfully installed, three will be pump tested for 24 hours each. Each of the remaining wells will be specific capacity tested for a period of four hours. Groundwater extracted during development, pump testing and specific capacity testing will be sampled and analyzed.
- 3.2.1.d As described in Section 2.1.1, it is estimated from existing data that the aquifer underlying the site will yield an average of 25 gpm per well. Given the complex limestone hydrogeology; however, the actual flow from a well could vary from zero to 1,000 gpm, depending on whether or not the well intersects a productive fracture zone. For this design, it will be assumed that each well will produce from 15 to 35 gpm, for an average of 25 gpm. Based on this assumption, and during installation of the extraction wells, a boring which does not appear capable of being converted to an extraction well having a pumping capacity of 15 to 35 gpm will be plugged and abandoned. Two basic criteria will be used to determine if a borehole will be completed as a well or abandoned:
- During air hammer drilling, air forced into the borehole displaces groundwater from the aquifer out of the well. A shroud is generally placed around the riser to capture this displaced water. Water is then funnelled into a 55 gallon drum or other container. The amount of water produced can be measured on a time scale and converted to a "flow rate" of gallons displaced per minute. Experience indicates that the flowrate of displaced water is roughly twice the potential yield of the borehole. Based on this, the criteria for accepting a borehole for completion as well will be that the water produced during air hammer drilling is approximately 30 to 70 gpm.

- Cuttings produced during drilling will be examined and logged. In order for a borehole to be converted to a well, there must be 10 to 15 feet of medium sand or coarser alluvial material existing above the top of bedrock at that borehole location.

3.2.2 Extraction Well Design Criteria

3.2.2.a Basic extraction well design criteria are the following:

- A minimum twelve (12) inch diameter borehole will be drilled at the ten selected well bores to allow the placement of a six (6) inch diameter casing and screen, and a minimum of three inches of gravel pack. Wells will be constructed with six (6) inch inside diameter galvanized iron casing and continuous "v" slot stainless steel screen.
- Well design will include careful specification of gravel pack and screen slot size to ensure maximum well efficiency. Slot size selection will be based on 90% retention of the filter pack, and the filter pack will be based on grain-size distribution of the aquifer.
- Wells will be drilled at least ten (10) feet into the Tuscumbia Limestone and screened over at least a twenty foot interval that extends from the aquifer in the upper bedrock upwards into the basal overburden aquifer. The depth to the top of bedrock will be approximately calculated using the top of Tuscumbia Limestone structure map (Figure 2-2). Data from driller logs included in the Geraghty & Miller reports [Ref. 8.17 and 8.25] shows that the upper bedrock aquifer in the Contaminated Waste Burn Trenches area will be encountered six to eight feet into the formation and can vary from two to twenty feet in thickness. Data to determine depth to this aquifer does not exist in the Open Burn Area and Open Detonation Area, but will be assumed to be ten feet into the formation. Every well will be logged to determine the depth and extent of this aquifer zone, and this data will be used to determine screen length and interval.

3.2.2.b Because Unit 2 is considered a hazardous waste site governed under the Resource Conservation and Recovery Act (RCRA), disposal of Waste Material (drill cuttings, development water, sludges, precipitates, and disposable equipment) generated at the site is governed by federal and state hazardous waste disposal regulations and rules. Waste Materials must be sampled and analyzed to determine if they are hazardous in order to determine proper disposal procedures. A Waste Disposal Plan will be prepared by Ebasco and approved by ADEM prior to initiating any site work at Unit 2.

3.3 DESIGN OF GROUNDWATER TREATMENT SYSTEM

The information presented in this section is based on currently available information about the Unit 2 site. This information will be reevaluated upon completion of the Ebasco Field Program. Any modifications to the conceptual groundwater treatment system design will be reflected in the ICM Design documents.

3.3.1 Process Design Consideration

3.3.1.a The design of the UV/oxidation process shall consider several important parameters including flow rate, nature and concentrations of contaminants and other oxidizable constituents, UV dosage, H_2O_2 dosage and reaction time requirements. The maximum design flow rate is projected to be 250 gpm. The primary contaminant of concern is Total Chlorinated Hydrocarbons, primarily TCE, at an average influent concentration of 30,000 ppb (see Section 2.2.a). Table 3-1 presents the estimated average concentrations of the contaminants detected at Unit 2. If contaminants are allowed to mix properly in an equalization tank, it is assumed that these average concentrations will approximately equal the influent concentrations to the treatment system. The treatment system will be designed to remove organic contaminants to below the estimated regulatory limits shown in Table 3-1.

3.3.1.b The UV dosage and H_2O_2 dosage can be determined based on the following equations.

$$K_{TCE} = -1/It \ln (C_e/C_i)$$

$$D = It = -1/k \ln (C_e/C_i)$$

where K_{TCE} = TCE oxidation rate constant, gal/KW-min

I = total UV intensity in the reactor, KW/gal

t = oxidation time, min

C_e = effluent TCE concentration, ug/l

C_i = influent TCE concentration, ug/l

D = UV dosage, KW-min/gal

3.3.2 Process Costing Basis

3.3.2.a Pretreatment is often required if: (1) iron is greater than 2 mg/l, (2) alkalinity is greater than 200 mg/l, (3) total suspended solids is greater than 5 mg/l, or (4) turbidity is greater than 10 NTU. Groundwater quality information was obtained from existing monitoring wells at Unit 2 by Ebasco in July, 1993. The following maximum values were obtained: (1) iron was 150 mg/L, (2) TSS was 1,600 mg/L, (3) chemical oxygen demand was 92 mg/L and (4) manganese was 9.8 mg/L. Based on these concentrations, pretreatment will be required to remove iron and TSS to enhance the advanced oxidation process performance and would likely consist of coagulation, flocculation, precipitation and filtration. The extent of pretreatment required for the ICM will be determined based on the results of the Ebasco Field Program.

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SECTION 4.0 HEALTH AND SAFETY PROGRAM

- 4.0.a The Health and Safety Program for this project is based on activity occurring at the Unit 2 site during design tasks. Health and Safety Requirements for the Ebasco Field Program will be discussed in other documents. Project requirements during design will include several site visits by various members of the Ebasco Design Team. The purpose of the site visits is to obtain site specific information for the design and will not include intrusive activities. A limited Health and Safety Plan developed for this project will be implemented during these visits. The limited Health and Safety Plan is included as **Appendix A** of this Work Plan.
- 4.0.b Design activities will include the development of a Design Analysis Report. The design analysis will include evaluation of the Health and Safety provisions to be required at the Unit 2 site during implementation of the project. Information from the Design Analysis Report will be used to prepare a Site Specific Health and Safety Plan (Task 9) and the Safety, Health and Emergency Response section of the Specifications (Task 3) to be included in the Contract Bid Package. A detailed list of the elements to be addressed in the Site Specific Health and Safety Plan is included in Section 5.9 of this Work Plan.